

Research Note 82-17

DEVELOPMENT AND EVALUATION OF A STABILIZED
GUNNERY TRAINING PROGRAM

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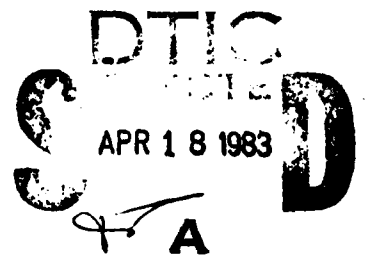
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<p>A program to train M60A3 tank gunners in stabilized gunnery was developed, tried out, revised, and tried out again on a sample of soldiers. While experimental groups acquired significantly more knowledge about stabilized gunnery techniques than did control groups, they did not perform significantly better than controls on the criterion test.</p>										

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FOREWORD

The Fort Knox Field Unit has a continuing research program on performance problems associated with the Army's new armor systems. The Weapon System Training Team is specifically concerned with training solutions to those performance problems.

Due to advances in the technology of stabilization, modern main battle tanks can be fired accurately while on the move. To realize the full potential of these armor systems, tank gunners must be trained to fire on stationary and moving targets from a moving platform. However, live-fire exercises are prohibitively expensive in terms of fuel and ammunition costs. Thus, stabilized gunnery training must consist of off-the-tank instruction or dry-fire exercises.

In this report, the authors describe the development and evaluation of a stabilized gunnery training program for the M60A3 main battle tank. Three training products were developed: a knowledge videotape for presenting information about stabilized gunnery, a practice videotape for practicing the timing skill involved in stabilized gunnery, and a series of on-tank exercises which do not require live-fire. The on-tank exercises were not tested. Evaluations of the videotapes showed that the knowledge tape was an effective training device but the practice tape was not. The knowledge videotape was designed to be used in armor OSUT with commonly available equipment. Nevertheless, the methods and findings of the present have applications to unit training and training on other stabilized tanks.

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PREFACE

This is the Final Report of Part II of a two-part project entitled "Research on Armor Weapon System Employment Parameters: Small Crew Performance Estimates and Moving Platform Stabilized Gunnery Training Techniques." The report describes activities undertaken to develop and evaluate two versions of a special program to train OSUT soldiers in moving platform gunnery. A literature review and analysis of the stabilized gunnery task were presented in an interim report (Author, 1981); a later interim report (Harris, Goldberg, and Morrison, 1982) documented development of the training program.

The work reported here was performed at the Fort Knox Office of the Human Resources Research Organization (HumRRO) under Contract No. MDA 903-80-C-0529 with the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI).

Dr. Robert W. Bauer, the Contracting Officer's Technical Representative (COTR), provided overall administrative and technical guidance. He was represented on this part of the project by Dr. Steven L. Goldberg, the assistant COTR, who monitored the work, and contributed substantially to the planning and conceptual phases. Dr. John E. Morrison, also of ARI, assisted in the planning and conceptual phases and contributed significantly to the design and analysis aspects of the evaluation.

The HumRRO Project Director was Dr. Elaine N. Taylor. HumRRO personnel who worked on the project included Karen G. Drucker, Janette E. Ford, Bridgette K. O'Brien, William C. Osborn, and Richard G. Woods.

The authors would particularly like to thank:

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DEVELOPMENT AND EVALUATION OF A STABILIZED GUNNERY TRAINING PROGRAM

BRIEF

Requirement:

To develop, tryout, and revise a stabilized gunnery training program for the M60A3 tank for use in Armor One Station Unit Training (OSUT).

Procedure:

The training program content was derived from literature on stabilized gunnery, interviews of subject matter experts, and a hands-on orientation to M60A3 stabilized gunnery. The program material consisted of three products: (1) a videotape for presenting information on stabilized gunnery, (2) an inexpensive training device for practicing the timing skills of stabilized gunnery, and (3) hands-on exercises for practicing skills learned from the videotape and training device on actual M60A3 equipment. The videotape training materials were tried out, revised, and tried out again. The hands-on exercises were not tried out.

Findings:

The stabilized gunnery knowledge videotape is an effective procedure by which to present information on moving platform gunnery to soldiers. The stabilized gunnery practice tape device enabled soldiers to gain confidence both in their ability to anticipate apparent reticle movement and respond to the movement. The device is of little value, however, in training soldiers to perform the tracking element of stabilized gunnery.

Use:

The videotape can be group-administered using equipment available in any OSUT battalion. The inexpensive training device can be set up in a dayroom or corner of a classroom. The M60A3 tank stabilized exercises can be practiced anytime a soldier is in the Gunner's seat and the tank is moving, for example, from the motorpool to the firing range or the driving course.

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DEVELOPMENT AND EVALUATION OF A STABILIZED GUNNERY TRAINING PROGRAM

INTRODUCTION

Advances in stabilized optics and fire control systems and requirements for a moving gun platform for Armor have resulted in the development of three battle tanks which can be fired on-the-move; the M60A1AOS, the M60A3, and the M1. Doctrine developed for Armor employment stresses this shoot-on-the-move capability. Battlefield tactics written for the ground combined arms force of the M1 tank, M2 infantry fighting vehicle and M3 cavalry fighting vehicle employ shoot-on-the move techniques in all situations except the static defense and for very long range precision gunnery where the firing vehicle is beyond the range of the threat vehicle. There is some evidence that the shoot-on-the-move capability of stabilized tanks is not being used as intended. As Ogorkiewicz (1976) points out:

" . . . there has been continued scepticism about the claims that the existing systems enable tanks to fire on the move, if this implies firing with anything like the accuracy possible at the halt. In fact, it is usually conceded that the main benefit to be derived from the existing stabilization systems is . . . to acquire targets on the move and to lay the gun so that a minimum of fine adjustment and time is required when the tank comes to a short halt to fire with the high accuracy of which it is then capable."

He goes on to suggest that "more elaborate stabilization systems than those based on two rate gyros mounted in the turret" may enable tank crews to come closer to the desired objective of firing on the move with a high hit probability.

The introduction of stabilization requires the development of specific training for operators of stabilized gun systems--training that differs in various respects from training for stationary gunnery. This report documents the development and tryout of a program focusing on such training for M60A3 stabilized gunnery in one station unit training (OSUT) and describes three research products. The M60A3 tank was chosen over the M60A1AOS because it has the more sophisticated stabilization system and more closely resembles the fire control system on the M1 which had not entered the OSUT inventory when the project began. The work is described in three phases: (1) Determine program content, (2) develop training material, and (3) tryout materials.

DETERMINE PROGRAM CONTENT

The development of effective training proceeds from a base of familiarity with the subject material. To enhance staff familiarity with the M60A3 tank system three activities were undertaken. The three activities were:

1. Literature review.
2. M60A3 orientation.
3. Subject matter expert (SME) interviews.

These activities occurred simultaneously and information gathered during one activity often clarified the scope of another. When the reviews, orientation, and interviews were completed, the content and focus of the program was determined.

Literature Review

In an earlier report (Author, 1981) a literature review was conducted to collect information on training strategies for moving platform stabilized gunnery. Behavioral implications or aspects of stabilization and its effect on training techniques were also considered. The articles examined covered the mechanics of stabilization, helicopter gunnery, trends in tank technology and Soviet training techniques. The literature, however, did not provide specific information about stabilized gunnery training. Six additional articles were reviewed since the earlier report was published (see Appendix A). These six articles covered aerial gunnery, the aerial training device 3-A-2, and gunnery training for tank crews. They provided no specific information about stabilized gunnery training.

A review of relevant field manuals (U.S. Army, 1977) and technical manuals (U.S. Army 1979) indicated two principles that must be followed when firing on the move:

1. Treat each round as a separate engagement. When firing on the move, particularly against moving targets, the rapidly changing tank-to-target relationship makes BOT difficult, if not impossible, to use.
2. Fire only when the gun tube is over the front or rear fenders. The smaller the acute angle between the gun and the line of travel, the better the stabilization. Therefore, fire over the flank only as a last resort.

M60A3 Orientation

After reviewing the "arrangement" of both the Gunner and Tank Commander stations, to include the operation of the fire control system, dry fire target engagements were run at various speeds over progressively rougher terrain. In addition to clarifying the mechanics and operation of stabilization on an M60A3, the orientation clarified vividly the major difference between firing from a stationary tank and firing from a moving tank.

The tank stabilization system of the M60A3 tank is designed to keep the gun tube and sights at the same elevation and direction regardless of the up-and-down or side-to-side movement of the tank. Thus, stabilization aids the gunner in keeping the reticle on target. Nevertheless, there are "error" inputs into this man-machine system which tend to draw the target off the reticle cross hairs, inducing apparent reticle movement with respect to target scene. A primary source of error input, common to moving platform and stationary gunnery, is movement of target relative to firing tank. The critical difference between the two gunnery modes is that, in moving platform gunnery, apparent reticle movement can also be caused by movement of the firing tank. Fortunately, these error sources are somewhat predictable and can be corrected by adjustments in tracking.

Two other error inputs are caused by limitations of the stabilization system itself. The first error source is due to tank movements too large or too fast for the stabilization system to compensate. The second is caused by the linkage of the gun and the sight: If the linkage has some play in it, the sights will appear to jiggle.¹ These errors also induce apparent reticle movement. However, both errors are too fast and unpredictable to be corrected by tracking adjustments. Experienced M60A3 gunners report that to overcome the seemingly random sight movement, the gunner must be able to time his shot because the cross hairs are on the target only momentarily; that is, he must anticipate when the target will approach the center of the reticle and lead and fire prior to its reaching that point. This timing skill is a gunnery component peculiar to firing on the move.

SME Interviews

The interviews with SME were conducted informally, either individually or in groups of four to five soldiers. Their experience in terms of M60A3 tank rounds fired on-the-move ranged from only dry-fire exercises on the tank up to one NCO who fired "3500-4000 rounds." In all, 14 soldiers were interviewed. Generally, the interviews were open-ended

¹Discussions with TRADOC Systems Manager (TSM) personnel indicated that much of the "sight jiggle" in early production M60A3 tanks was due to a faulty gun/sight linkage. Mechanical improvements to the older sights have minimized the problem, however.

with the soldier's response to a particular question leading naturally to other questions. Some of the information gathered from these interview sessions proved useful during the development phase of the project. Following are the questions whose answers helped determine the program content:

1. When firing the M60A3, what is harder about firing from a moving platform (at least the first few times) than firing from a stationary platform?

Answers:

- a. Timing "pattern"¹ about the target.
- b. Changes in speed of apparent reticle movement when firing tank changes speed.
- c. "Jitter" in the sight.

2. What do you do to compensate?

Answers:

- a. Time shot. This timing, or anticipating, skill is a gunnery component peculiar to firing on the move.
- b. Learn to recognize drift patterns and fire on first return to target.
- c. Ambush the target.
- d. Fire lots of rounds.
- e. Let stabilization system operate around target area; Gunner just track target.
- f. Know speed at which stabilization system smooths out.

3. How do you sit in the Gunner's seat when firing from a moving platform?

Answers:

- a. Brace self and take-up same sight picture.
- b. Press head harder on head rest.
- c. Remain rigid but relaxed; roll with the punches.
- d. Rigid but braced feet, head, and hands.
- e. Firm head rest--press down firmer in seat--place feet flat and centered below Gunner's control handles.

¹These "patterns" are the seemingly random reticle movements caused by the three types of error inputs inherent in moving platform gunnery.

f. As speed increases and terrain gets rougher, keep body rigid from waist up to keep head in brow pad.

4. Can burst-on-target and subsequent fire command still be used to adjust fire when the M60A3 is moving?

Answer:

a. No, because tank movement causes left-right relationship of target and burst to be distorted.

Information gathered from the orientation, interviews, and reviews was consolidated and the following principles of firing on the move emerged:

1. Treat each round as a separate engagement.
2. Know the "sweet spot" for your tank.¹
3. Know reticle drift pattern for your tank.
4. Anticipate "pattern" of reticle movement.
5. Anticipate movement of tank.
6. Fire between front or rear fenders.
7. Fire over flank only as last resort.
8. Press head into browpad, back against seat back.
9. Allow stabilization system to do its work.
10. Lase and lead with either thumb switch.
11. Know that when turret is in STAB mode, don't have to squeeze palm switches to traverse or elevate and depress turret.
12. Know there is no such thing as a "perfect" sight picture.
13. Know that main gun, within limits, maintains fixed orientation in space regardless of vehicle motion.
14. Take up same sight picture.

¹The "sweet spot" speed is the speed where the apparent reticle movement is minimal. The sweet spot differs for each tank depending on such factors as terrain type.

The development of a training program centered around these principles was undertaken. But since the program was to be used during the conduct of fire phase of M60A3 OSUT, certain constraints had to be considered: The relative inexperience of the soldiers; the limits on available time; and, a scarcity of tanks, main gun ammunition, gasoline, and ranges suitable for moving tank gunnery. Thus both the analytically derived gunnery principles and the prevailing program constraints guided the design of training materials.

DEVELOP TRAINING MATERIALS

The developmental approach to training was straightforward: provide performance-oriented instructional events in which the soldier could acquire, (a) knowledge of the relevant stabilized gunnery principles and (b) skill in their application. Too, the approach called for a training medium that was inexpensive yet permitted a level of visual realism sufficient to display realistic stabilized reticle movement in relation to recognizable targets. A video display linked to a simple response mechanism met these requirements.

Tank targets at various speeds and ranges were filmed through the stabilized sight of an M60A3 moving tank. Films of these targets were sorted out on the basis of clarity and demonstration of the stabilized gunnery principles; then, arranged in terms of engagement difficulty. Two videotapes, one for training knowledge of stabilized gunnery principles, the other for practicing those principles were prepared. After the videotapes were prepared, a series of exercises was developed to enable soldiers to practice on M60A3 tanks what they had learned on the videotapes. The exercises are designed to be used anytime the soldier is in the Gunner's seat and the tank is moving.

Videotape Preparation

Two videotapes were prepared. The first, a knowledge videotape (KT), presents the firing on the move principles in terms of their knowledge components. The second, a practice videotape (PT), when coupled with a simple response device enables practice of some skill components of the firing on the move principles. In general, the videotapes are to be used during training to:

1. Familiarize soldiers with the "patterns" of reticle movement about the aim point during stabilized gunnery engagements. (KT)
2. Demonstrate the correct point in the "pattern" to lase and fire. (KT)
3. Provide practice in "anticipating" the reticle movement about the aim point during stabilized gunnery engagements. (PT)
4. Provide practice in lasing and firing. (PT)

Knowledge Videotape

Twelve situations are presented in increasing order of engagement difficulty. Engagement difficulty is presumed to increase as range to target increases and firing tank speed, target speed, or both increase.

The M60A3 orientation focused the scope of the training content on target engagements where the firing tank is traveling at speeds of 10 MPH or less, the target tank is stationary or traveling at 10 MPH, and the firing tank-to-target range is 1600 meters or less. The 12 situations are presented in tabular form in Table 1. Situations 3, 6, and 8 are split screen presentations of Situations 1/2, 4/5, and 5/7, respectively. This permits soldiers to compare and contrast sight picture differences when range differs (Situation 3); when terrain and range differ (Situation 6) and when firing tank speed differs (Situation 8). Situation 12 is an example of how the reticle vibration tends to "smooth out" at certain speeds. The 12 situations are followed by five new situations in which the correct lase and fire points during the reticle movement are demonstrated. In addition, on the last two situations, the correct technique for adjusting fire is discussed and demonstrated. Narration describing the firing on the move principles as they are presented is provided throughout the videotape.

The principles presented on the videotape are:

- Three contact points
 - Press head firmly against browpad.
 - Press lower back against Gunner's seat backrest.
 - Place feet flat on turret floor.
- Reticle movement
 - Movement caused by stabilization system.
 - Influenced by speed of tank and type of terrain.
 - The speed where vibration in sight picture smooths out and reticle jumps around less is the "sweet spot."
- Tracking
 - Let stabilization system make fine corrections around the target area.
 - Use Gunner's control handles to track the target.
- Front deck
 - Lase and fire only when gun tube is over the front deck, unless . . .
 - You encounter a surprise target on your flank.
- Lase and fire
 - Anticipate reticle movement toward center of mass.
 - Lase and fire immediately when it moves toward center of mass.
 - Depress and hold either palm switch.
 - Track for at least 1-1/2 seconds.
 - Depress and release either Gunner's thumb switch.

Table 1
Situations For Knowledge Videotape

SITUATION	FIRING TANK		TARGET		
	Speed (MPH)	Terrain	Speed (MPH)	Direction	Range (Meters)
1	5	Smooth	Stationary	Facing	1400M
2	5	Smooth	Stationary	Facing	1600M
3-1/2	5	Smooth	Stationary	Facing	1400/1600M
4	5	Smooth	10	Right to Left	1600M
5	5	Rough	10	Left to Right	1000-500M
6-4/5	5	S/R	10	Right to Left/ Left to Right	16M/10-5M
7	10	Rough	10	Right to Left	1000-500M
8-5/7	5/10	Rough	10	Left to Right/ Right to Left	1000-500M
9	5	Rough	10	Right to Left	1200-500M
10	10	Rough	10	Advancing	1000-500M
11	5-7	Rough	10	Retreating	700-500M
12	20	Smooth	Stationary	Side	1100M

- Adjust fire
 - Reengage technique to adjust fire.
 - Release and then depress Gunner's palm switch.
 - Track target.
 - Release.
 - Fire a second round.

The script for the moving platform gunnery knowledge videotape is presented at Appendix B.

Practice Videotape

The practice videotape presents 18 situations of 20 seconds each. The first nine situations are presented in increasing order of difficulty; then, the same nine situations are presented in random order. The videotape is to be used with a very simple mechanical response device called the Practice Tape Device (PTD) which includes a set of M60A3 Gunner handles and periscope. The Gunner handles are not responsive; the device provides practice only on timing (anticipating) not tracking. The device is designed so that the soldier observes the video display through the periscope and lases and fires when he thinks the sight picture is correct for lasing and firing. When the soldier thinks the sight picture is correct for lasing, he presses either Gunner's thumb switch to set lead and fire the laser. The videotape "freezes" and the accuracy of his response, in terms of deflection (left or right) and elevation (short or over), as well as the time to respond can be recorded and evaluated. The device is reactivated after the lasing response is recorded and the soldier presses either firing trigger when the sight picture is correct for firing. Again, the videotape "freezes" and the accuracy of his response as well as the time to respond can be recorded and evaluated.

M60A3 Exercise Preparation

A series of five exercises was developed to enable soldiers to practice on M60A3 tanks some of the things presented in the knowledge videotape and practiced using the device and practice videotape. The exercises comprise the essential requirements for acquiring proficiency in moving platform gunnery on the M60A3 tank. They should be practiced whenever possible. The practice can be done formally, during scheduled training time, or informally, whenever the tank is moving and the soldier is in the Gunner's position.

Exercises were developed to include:

- Exercise 1: Taking up the correct position in the Gunner's seat.
- Exercise 2: Determining the sweet spot for the tank on which he is the Gunner.

Exercise 3: Tracking targets when the tank is moving.

Exercise 4: Lasing and firing on targets when the tank is moving.

Exercise 5: Reengaging to adjust fire.

The exercises build on each other by requiring the soldier to do the preceding exercise (or use the information from it, i.e., the sweet spot) as part of the exercise he is doing. For example, during Exercise 3, the soldier takes up the correct position in the Gunner's seat and tells the Driver to move out slowly in the direction of the target and increase his speed until the tank's sweet spot is achieved. Then he practices the components regarding tracking targets. The exercises are presented in Appendix C.

TRY OUT TRAINING MATERIALS

This section of the report describes the initial tryout of the videotape training, results of the tryout, revisions to the program based on the results, and a second tryout and results. The tank stabilized gunnery exercises were not tried out.

Tryout I

Approach

Devices. Three training devices and one testing device were used during Tryout I. The first training device was the KT on principles of moving platform gunnery which experimental group Ss viewed. The second device, also for the experimental group, was the PT and PTD. In response to a fire command, Ss viewed, through a periscope, a videotape scene of a reticle "tracking" a target. They "fired" a laser on the gun by pressing appropriate switches when they anticipated the reticle approaching the center of mass of the target. The Gunner's handgrips provided no control over the movement of the reticle or any other aspect of the visual display. The third training device, used for the soldiers assigned to the control group, was a round sensing device. On this device, Ss were provided with a set of Gunner's handgrips, a periscope, and a static display of black and white bull's eye targets. They pressed the trigger switch on the gun controls and observed through the periscope for the simulation of round burst. Immediately, by manipulating a hand lever that was independent of the Gunner handgrips, they placed the point of a stylus on the spot where the flash of light was displayed. The Gunner's handgrips provided no control over the visual display, nor was there a reticle in the periscope. The round sensing device was chosen to equate control handle manipulation experience with that received by the experimental groups who used the PTD.

The Fire Control Combat Simulator (FCCS), which enables simulated target engagement in a stabilized mode, was used as the device for the criterion test. The FCCS was chosen over the M60A3 because of cost and support considerations. In addition, the FCCS provided a variety of reliable performance measures not available from an M60A3. The device, as described by Kottas and Bessemer (1979), consists of an instructor's console and a Gunner's station. The console "provides power control, self-test, program direction, and engagement start and stop commands. Two visual displays are provided by the console. A display monitor . . . provides a visual assessment of the Gunner's proficiency in . . . tracking and firing." At the Gunner's station, "an eyepiece allows the Gunner to view the action area as if viewing through the tank. The Gunner can observe terrain, target, and the (periscope) reticle. Through handle inputs, the Gunner can move the field of view (FOV) to acquire . . . track, lead, and fire on a target." The Gunner ranges to the target by pressing the lase/lead button. This fires the laser and sets the automatic lead. The FCCS was programmed for M60A3 stabilized gunnery.

To initiate each FCCS trial, S was given a ready signal and time to position himself in the brow-pad and grasp the gunner handgrips. He was then given a fire command, the display was turned on, and he tracked the target, lased, and fired. The display remained on until the round struck, either as a hit or a miss. If the round hit the target, the display went off automatically. If the round missed the target, the test administrator terminated the display.

The primary measures of performance on the PT and PTD were lasing time, lasing accuracy, firing time, and firing accuracy. The measures for the FCCS were lasing accuracy (number of correct lasings), firing accuracy (number of hits), and engagement time (time between fire command and firing).

Procedure. As Ss reported for the study, they were assigned randomly to one of two experimental groups or to a control group and then interviewed regarding their previous training. The training and testing sequence for experimental Ss was Knowledge Test, FCCS Pretest, KT, FCCS Posttest 1, PTD (18 or 36 trials), FCCS Posttest 2, Knowledge Test, and Exit Interview.

For control Ss the sequence was Knowledge Test, FCCS Pretest, Round Sensing, FCCS Posttest 1, Round Sensing, FCCS Posttest 2, Knowledge Test, and Exit Interview. The training and testing for each S was completed in one day, and required approximately two hours.

Design. As Table 2 indicates, one group of ten experimental Ss received 18 practice trials in lasing and firing at targets; the second experimental group of ten Ss received 36 trials. The ten control Ss received practice in round sensing in lieu of knowledge and practice in stabilized gunnery.

While the presentation of knowledge about stabilized gunnery and the provision for special practice in this kind of gunnery constituted the main treatment conditions, other conditions were also introduced. A summary of all treatment conditions for both experimental and control Ss is provided in Table 2. For convenience, Event numbers have been assigned to the various conditions.

Event 1, Entry Knowledge Test, in the form of a brief questionnaire, (see Appendix D), sought to assess S's knowledge of six principles of M60A3 stabilized gunnery prior to the presentation of the experimental program. The same test was given again at Event 7, thereby enabling a determination of how much knowledge was acquired. The FCCS Pretest (Event 2) was administered prior to any training. It was given again as Posttest 1 (Event 4) following presentation of stabilized gunnery knowledge or round sensing and again as Posttest 2 (Event 6) after experimental Ss had received practice in stabilized gunnery on the PTD and control Ss had once again received practice in round sensing.

Event 8, Exit Interview, was conducted so that Ss might provide important clues regarding their attitudes and reactions to the devices, and that suggestions about the probable usefulness of the devices and procedures for training other soldiers might result.

Table 2
Treatment Conditions for Tryout I

Event	Experimental 1	Experimental 2	Control
1	Entry Knowledge Test ^a	Entry Knowledge Test	Entry Knowledge Test
2	FCCS Pretest	FCCS Pretest	FCCS Pretest
3	Stabilized Gunnery Knowledge Tape	Stabilized Gunnery Knowledge Tape	Round Sensing
4	FCCS Posttest 1	FCCS Posttest 1	FCCS Posttest 1
5	Stabilized Gunnery Practice Tape (18 Trials)	Stabilized Gunnery Practice Tape (36 Trials)	Round Sensing
6	FCCS Posttest 2	FCCS Posttest 2	FCCS Posttest 2
7	Exit Knowledge Test	Exit Knowledge Test	Exit Knowledge Test
8	Exit Interview ^b	Exit Interview	Exit Interview

^aThe decision to administer the Knowledge Test was made after five subjects in each group had completed the study.

^bThe decision to administer the Exit Interview was made after eight subjects had completed training and testing; thus, the interviews were conducted with 15 experimental subjects (eight in E1 and 7 in E2) and 7 control subjects.

Subjects. Soldiers who recently completed M60A3 conduct of fire training in the OSUT program, 1st Training Brigade, Ft. Knox, Kentucky served as subjects. There were ten soldiers in each of the three groups. No systematic procedures were used in selecting subjects for the study, and soldiers were assigned randomly to groups once they arrived at the study site.

Results

The results of Tryout I are presented in three parts: evaluation of M60A3 knowledge test scores, analysis of the effects of stabilized gunnery practice, and analysis of FCCS performance scores.

M60A3 Stabilized Gunnery Knowledge Test. Table 3 presents pre-training and posttraining mean scores on the six-item Knowledge Test for the two experimental groups and the control group. As shown, the means increased from pre- to post-training for the experimental groups but not for the control. The reliability of these data was evaluated statistically.

Table 4 presents ANOVA results using a one between- and one within-subjects mixed design (Myers, 1979). Significant ($p < .005$) groups by pretest-posttest interaction was found suggesting that differences between pretest and posttest scores were not consistent for all groups. The Newman-Keuls procedure was used to analyze the specific nature of the interaction. These results are also noted in Table 3. As expected, they show that significant improvement between pretraining and posttraining administration of the knowledge test occurred for both experimental groups, but not for the control group. Furthermore, at posttesting each of the experimental groups had higher knowledge test scores than the control group. The two experimental groups, however, were not significantly different.

Table 3

Mean Scores for M60A3 Stabilized Gunnery Knowledge Test

<u>Group</u>	<u>Pre- Training</u>		<u>Post- Training</u>
Experimental 1	2.4		4.0
Experimental 2	1.4		5.2
Control	1.4		1.2

^aSignificantly different (Newman-Keuls) at $p < .05$

Table 4

M60A3 Stabilized Gunnery Knowledge Test

<u>Source of Variation</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>Significance</u>
Between					
Groups	25.4	2	12.7	14.11	<.001
Error _B (Ss within groups)	10.8	12	.9		
Within					
Tests	22.5	1	22.5	21.8	<.001
Groups X Tests	20.1	2	10.05	9.8	<.005
Error _W (Ss within groups X tests)	12.4	12	1.03		
Total	91.2	29			

$$F_{.999}(2,12) = 12.97$$

$$F_{.995}(2,12) = 8.51$$

$$F_{.999}(1,12) = 18.64$$

Stabilized Gunnery Practice. In Table 5, means of lasing time, lasing accuracy (as indicated by the periscope reticle crosshair within the target area when the S presses the lase/lead button), firing time, and firing accuracy (as indicated by the periscope reticle crosshair within the target area when S presses the firing trigger) are presented for the exercises received during practice for experimental groups. Time scores are summarized as mean seconds for a total of nine trials. With respect to lasing accuracy and firing accuracy, the maximum possible score was nine in each block.

One-way repeated measure ANOVAs were conducted by measure separately for each experimental group to analyze changes in performance over blocks of practice trials. These ANOVAs are presented in Appendix E. None of these eight ANOVAs indicated significant main effects for practice sets, suggesting that there was no improvement in lasing time, lasing accuracy, firing time, or firing accuracy for either experimental group during their practice on stabilized gunnery.

Table 5

Mean Scores on Stabilized Gunnery Practice Tape Device

Group by Measure	Block of Nine Practice Trials			
	1	2	3	4
<u>Lasing Time (Seconds)</u>				
Experimental Group 1	35.28	35.58		
Experimental Group 2	29.93	27.05	26.42	26.46
<u>Lasing Accuracy (Number Correct)</u>				
Experimental Group 1	7.3	7.7		
Experimental Group 2	7.1	7.6	7.8	7.9
<u>Firing Time (Seconds)</u>				
Experimental Group 1	39.78	36.18		
Experimental Group 2	35.04	35.88	33.03	34.16
<u>Firing Accuracy</u>				
Experimental Group 1	7.0	7.3		
Experimental Group 2	7.4	7.5	7.2	7.6

FCCS Performance Test. Three measures were taken for each S for each of three FCCS ten-trial¹ tests. These were lasing accuracy (number of correct lasings as indicated by a green "Range Correct" light appearing on the instructor's console when S pressed the lase/lead button), firing accuracy (number of hits as indicated by an "X" through the rectangular target on the instructor's console when S pressed the firing trigger) and average engagement time (average time between fire command and firing, as indicated by a stopwatch operated by the scorer).

Table 6 presents the means of these measures on the three FCCS tests for the two experimental groups and the control group. The ANOVA results from a one between- and one within-subjects mixed design, respectively, for each of the three FCCS performance scores are presented in Appendix E. For lasing accuracy, firing accuracy, and engagement time, there were no significant main effects or interactions.

¹The ten-trial test was five different engagements (three moving target, two stationary target) each engaged twice in random order.

Table 6

Mean FCCS Performance

Measure by Group	Pretest	Posttest 1	Posttest 2
<u>Lasing Accuracy (10 Possible)</u>			
Experimental			
Group 1	3.7	5.2	5.6
Experimental			
Group 2	4.3	4.3	4.7
Control			
Group	5.1	5.1	5.6
<u>Firing Accuracy (10 Possible)</u>			
Experimental			
Group 1	3.7	4.4	4.1
Experimental			
Group 2	3.4	3.0	3.2
Control			
Group	3.3	2.3	4.0
<u>Engagement Time (Seconds)</u>			
Experimental			
Group 1	12.6	12.4	12.5
Experimental			
Group 2	12.4	13.2	11.7
Control			
Group	10.7	10.2	10.0

One additional analysis was done for the FCCS data. The stationary target engagement results were examined separately from the moving target engagements. Stationary targets should be a purer test of the application of the training principles without superimposing tracking skill. Performance on the four stationary target engagements was analyzed using a directional *t* test for the three groups from Pretest to Posttest 1, Posttest 1 to Posttest 2, and Pretest to Posttest 2. In all cases, the results were not significant (all *ps* > .05). Figure 1 shows the firing accuracy for the stationary target engagements for each group across each treatment. Engagement 4 is the summation of one of the stationary targets engaged twice; Engagement 5 the summation for the second stationary target engaged twice. The maximum number of hits for each treatment condition for each group is 20 (ten Ss in each group by two targets).

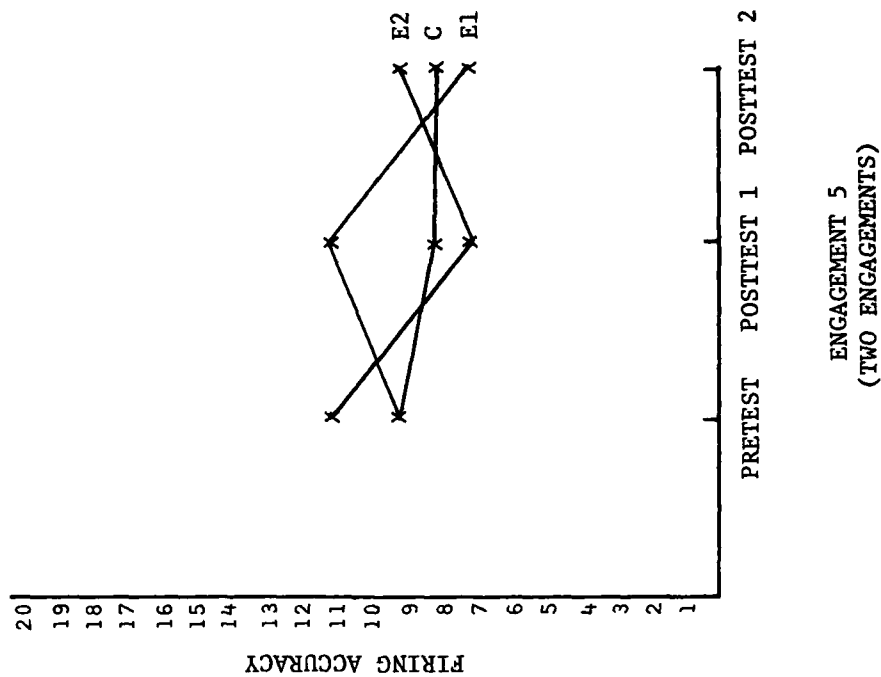
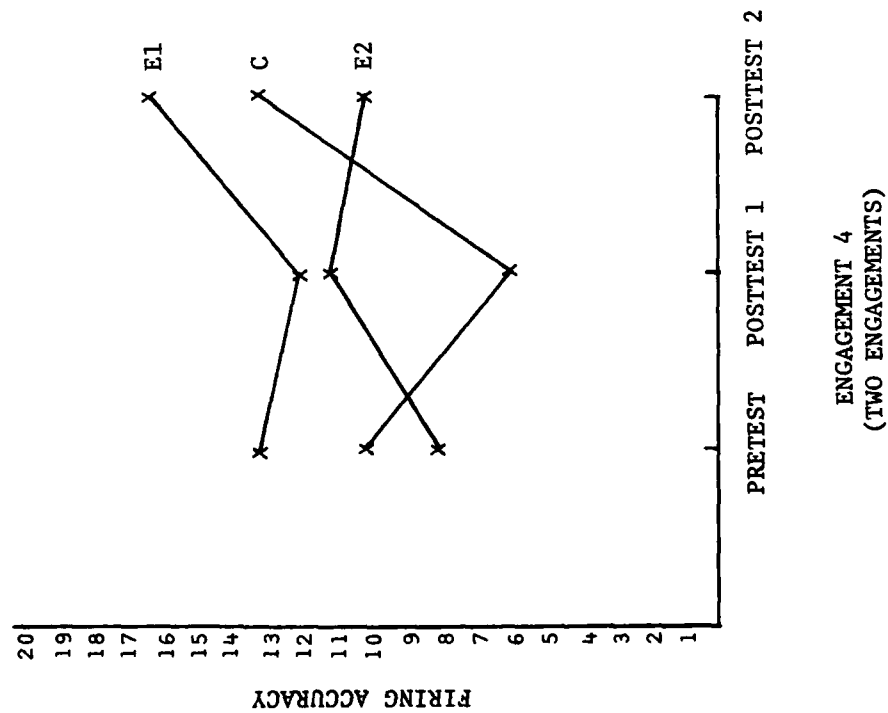


Figure 1. Firing accuracy for stationary engagements.

Discussion

The results of Tryout I were clear. While experimental Ss increased in their knowledge of stabilized gunnery, this knowledge did not improve their performance on the FCCS. Similarly, even though Ss received special practice in stabilized gunnery, the effects of this training on FCCS performance were negligible. In sum, then, the training program used in the tryout did not achieve the desired results.

During the process of analyzing the various data, considerable thought was given to ways to improve the training program. Exit interviews were also reviewed for this purpose, but they offered only limited guidance. Experimental Ss were almost equally divided in their preference for the PTD versus the FCCS. Complaints that KT was too long or repetitious were common.

Because Ss demonstrated that they had learned facts about stabilized gunnery, but could not reflect this learning in proficiency, the staff speculated that subjects had not had time to incorporate the learning into their repertory before they were required to perform the criterion task (the FCCS). In other words, they were still processing the information. These interpretations suggested the merit of changing the approach to measuring proficiency on the criterion task.

Tryout II

The purpose of Tryout II was to administer a revised experimental program for training soldiers in M60A3 stabilized gunnery. The program was revised to give experimental Ss sufficient practice to integrate moving platform gunnery knowledge into their skill repertoire. In general, the revised program differed from the initial one in two major respects: (1) an increase in the number of trials on the criterion task--the FCCS, and (2) a reduction in length of the KT.

The KT was modified in two significant ways. First, the length of the videotape was reduced by approximately one-third. This was done by decreasing the time for each of the first 12 situations from one minute to 20 seconds. Comments of Ss during Tryout I indicated that they "got the point" before the end of the one-minute segment and the long segment caused them to lose interest quickly. Four of the nine situations showing when to lase and fire were deleted, primarily in the interest of reducing time.

The second modification was to the script. More emphasis was placed on the notion of tracking the target while letting the stabilization system operate around the target area. The procedure to lase and fire was described twice while five situations (instead of the original nine) were presented as examples of when to lase and fire. Finally, a summary was presented at the end of the videotape which discussed the points emphasized during the presentation.

The proficiency measurement technique was modified by increasing the number of trials on the FCCS. More specific information about the substance of the revised proficiency measurement technique is provided in the following section.

Approach

As in the initial program, the revised program sought to teach moving platform gunnery skills to soldiers by providing them with special knowledge and practice in stabilized gunnery. Thus, as before, experimental Ss were provided videotape instruction on the principles of stabilized gunnery (KT), and then given special practice in lasing and firing at videotape targets (PTD). Control Ss were given practice in round sensing in lieu of knowledge and practice in stabilized gunnery. Following training, both experimental and control Ss were tested on the same criterion task (FCCS). Thus, the training procedures of this study were essentially the same as the previous study. Main study differences, as will be seen, were in the nature of performance assessment procedures.

Devices. The devices for Tryout II were the same as for Tryout I, with the exception previously noted concerning revisions to the KT.

Design. A summary of the treatment conditions employed in Tryout II is shown in Table 7.

Table 7
Treatment Conditions for Tryout II

Event	Groups	
	Experimental	Control
1	Entry Knowledge Test	Entry Knowledge Test
2	FCCS Pretest	FCCS Pretest
3	Stabilized Gunnery Knowledge Tape	Round Sensing
4	Stabilized Gunnery Practice Tape (36 trials)	Round Sensing
5	FCCS Posttest (Part 1)	FCCS Posttest (Part 1)
6	FCCS Posttest (Part 2)	FCCS Posttest (Part 2)
7	Exit Knowledge Test	Exit Knowledge Test
8	Exit Interview	Exit Interview

The second tryout procedure differed from the first as follows: (1) Only one experimental group was used; (2) The stabilized gunnery practice tape was administered immediately after the knowledge tape, i.e., no criterion testing on the FCCS intervened; (3) The FCCS test was administered as a two-part Posttest that came only after all training was completed.

The table shows that both groups completed the knowledge test before and after the study (Events 1 and 7), undertook the FCCS test on three separate occasions (Events 2, 5 and 6), and participated in an exit interview (Event 8) at the end of data gathering.

Not reflected in Table 7 are changes to the testing procedure on the FCCS. Rather than the ten-trial pretest (two repetitions of five target engagement scenarios) given in the first field trial, the pretest in this second phase consisted of 12 trials, six each on two scenarios presented in closed random sequence. The two scenarios were selected from the basic set of five scenarios used in Tryout I based on the target hits of that study.

One scenario (Scenario 1) simulated a firing tank with HEP ammunition selected, moving at 10 mph over rough terrain, with the target tank moving from right to left at 10 mph at a range of 1500 meters. The other scenario (Scenario 2) simulated a firing tank with APDS ammunition selected, moving at 10 mph over medium terrain, with the target tank stationary at 2500 meters. In Tryout I, these were the most difficult (20% hits) and easiest (55% hits), respectively, of the five scenarios used. These scenarios were used to increase the number of data points on a scenario, to reduce the intra-scenario variability, and to see if differences in performance resulted.

Following the completion of training (KT and PTD, or round sensing), each S was given the two-part FCCS criterion test. Posttest, Part 1, consisted of 24 trials each on the two scenarios used in pretesting (Scenario 1 and Scenario 2), and the testing procedures were identical. Scores were recorded in four blocks, with 12 trials in each block.

In Posttest, Part 2, Ss were instructed to reengage the target if their first round was a miss. This was employed to obtain more specific information about reengagement skills of Ss, since little was known about this capability. There were two scenarios for Posttest, Part 2, selected to increase the likelihood of a first round miss. These were:

- Scenario 3: Firing tank with APDS ammunition selected, moving at 20 mph over medium terrain and target moving from left to right at 30 mph at a range of 2500 meters.
- Scenario 4: Firing tank with APDS ammunition selected, moving at 20 mph over rough terrain and target moving from right to left at 30 mph at a range of 2500 meters.

During Posttest, Part 2, if the first round was a miss, the display remained on in order that the subject might reengage the target. If the first round was a hit, the display automatically went off. Subjects were given six trials on each of the two scenarios in a closed random sequence.

The primary measures of performance obtained for PTD were the same as during Tryout I: lasing time, lasing accuracy, firing time, and firing accuracy. For the FCCS, the following measures were obtained: lasing accuracy, firing accuracy, lasing plus firing accuracy, and engagement time. In the second part of the posttest, relaying the reticle, time to relase, accuracy of relase, time to refire, and accuracy of refire were recorded.

Subjects. The subjects were 24 M60A3 soldiers who had completed the Conduct of Fire training in the OSUT program, 1st Training Brigade, Fort Knox, Kentucky. Soldiers were assigned randomly (12 each) to the experimental or control group.

Results

The results of Tryout II are presented in three parts: evaluation of M60A3 knowledge test scores, analysis of the effects of stabilized gunnery practice, and analysis of FCCS performance scores.

M60A3 Stabilized Gunnery Knowledge Test. Table 8 presents pretraining and posttraining mean scores on the knowledge test for the experimental group and the control group. Table 9 presents ANOVA results using a one between- and one within-subjects mixed design (Myers, 1979). Significant ($p < .001$) main effects were found for group treatments and for pretest versus posttest. In addition, a significant ($p < .001$) groups by pretest-posttest interaction was found suggesting that differences between pretest and posttest scores were not consistent for all groups. The Newman-Keuls procedure was used to analyze the specific nature of the interaction. These results are also noted in Table 8.

Table 8

Mean Scores for M60A3 Stabilized Gunnery Knowledge Test

	Pretraining	Posttraining
Experimental	3.75	7.00
Control	3.33	3.75

^aSignificantly different (Newman-Keuls) at $p < .05$

Table 9
Analysis of Variance
M60A3 Stabilized Gunnery Knowledge Test

Source of Variation	SS	df	MS	F	Significance
Between Groups	40.34	1	40.34	29.02	< .001
Error _B (Ss within groups)	30.58	22	1.39		
Within Tests	40.34	1	79.10	79.10	< .001
Groups X Tests	24.07	1	47.20	47.20	< .001
Error _W (Ss within groups X tests)	11.31	22			
Total	146.64	47			

$$F_{.999}(1,22) = 14.59$$

Stabilized Gunnery Practice. In Table 10, means for lasing time, lasing accuracy, firing time, and firing accuracy are presented for each of four blocks of nine trials on the PTD for the experimental group.

Table 10
Mean Scores on Stabilized Gunnery Practice Tape Device

Type of Score	Blocks of Nine Practice Trials			
	1	2	3	4
Lasing Time (Seconds)	32.62	27.73	26.35	25.62
Lasing Accuracy	7.67	8.58	8.00	8.42
Firing Time (Seconds)	36.27	36.12	37.17	35.47
Firing Accuracy	8.08	8.08	8.08	7.67

One-way repeated measure ANOVAs were performed for each type of score to assess changes in performance across blocks. These ANOVAs are presented in Appendix F. Only the F for Blocks on the Firing Time measure was significant ($p < .01$); however, this significance was not due to any consistent trend (Table 10).

FCCS Performance Test. The scores of Ss were tabulated in blocks of 12 trials each (six of Scenario 1 and six of Scenario 2). There was one pretest block and, in Posttest, Part 1, four posttest blocks. The scores recorded for each S on these blocks were lasing accuracy, firing accuracy, lasing accuracy plus firing accuracy, and engagement time. Table 11 presents the means for these scores for each block for both experimental and control groups.

Table 11
Mean FCCS Performance Scores
for Pretest and Posttest, Part 1

Measure by Group	Pretest	Post 1	Post 2	Post 3	Post 4
<u>Lasing Accuracy</u>					
Experimental	5.91	5.58	6.25	5.91	7.75
Control	4.25	3.75	4.50	5.17	4.25
<u>Firing Accuracy</u>					
Experimental	4.25	4.67	4.33	5.33	5.00
Control	3.58	4.17	4.75	4.92	4.25
<u>Lasing Accuracy & Firing Accuracy</u>					
Experimental	2.83	2.75	2.58	2.75	3.58
Control	1.83	1.67	2.08	2.75	1.92
<u>Engagement Time (Seconds)</u>					
Experimental	11.65	11.58	10.81	9.65	10.13
Control	12.87	11.60	10.99	9.80	10.19

The ANOVA results from a one between- and one within-subjects mixed design, respectively, for each of the four FCCS performance scores are also in Appendix F. For lasing accuracy, firing accuracy, and lasing accuracy plus firing accuracy, there were no significant main effects or interactions. For engagement time, the main effect of block of trials was significant ($p < .05$).

Various other analyses of FCCS test scores were undertaken to isolate possible effects. For example, an analysis of variance of only the four blocks of the Posttest, Part 1, was undertaken. The scores analyzed were as before: lasing accuracy, firing accuracy, lasing plus firing accuracy, and engagement time. The results showed two significant ($ps < .05$) F values for lasing accuracy, one for the main effect of blocks and one for the interaction of blocks times groups (see Table F-7). No other values were significant.

An analysis was undertaken to assess separately each of the two scenarios used in the Pretest and the Posttest, Part 1.¹ An analysis of variance of firing accuracy, lasing accuracy, and engagement time was performed for each scenario. For the less difficult scenario (Scenario 2), two significant ($ps < .001$) effects were found (Table F-8) for lasing accuracy: the main effect of blocks and the interaction of blocks and groups. For engagement time (Table F-9) a significant ($p < .001$) effect was found for blocks. No other significant effects were found for Scenario 2.

For the more difficult scenario (Scenario 1), no significant effects were found for any of the scores. Plots of the means of the two groups on the three scores confirmed that little if any learning occurred.

The results of FCCS Posttest, Part 2, are reported in Tables 12 and 13. In the Part 2 Posttest, only ten Ss in each group participated; two in each original group were lost due to equipment failure. Each S received six trials on each of two scenarios.² Table 12 gives the basic frequency data for Posttest, Part 2.

The frequencies in Table 12 were examined in various ways, but clear cut trends failed to emerge.

Table 13 reports the mean engagement times for the two groups. These times pertain only to the second round fired. The results show that the means for the groups are essentially the same.

¹Scenario 1: Firing tank with HEP ammunition selected, moving 10 mph over rough terrain with the target moving from right to left at 10 mph at a range of 1500 meters (Difficult).

Scenario 2: Firing tank with APDS ammunition selected, moving 10 mph over medium terrain, with the target tank stationary at 2500 meters (Easy).

²Scenario 3: Firing tank with APDS ammunition selected, moving at 20 mph over medium terrain and target moving from left to right at 30 mph at a range of 2500 meters.

Scenario 4: Firing tank with APDS ammunition selected, moving at 20 mph over rough terrain and target moving from right to left at 30 mph at a range of 2500 meters.

Table 12

Frequency of Hits, Misses, and No Fires
by Scenario and Group
(Posttest, Part 2)

Group	Scenario 3					Scenario 4				
	1st round	2nd round		No	Sum	1st round	2nd round		No	Sum
	Hit	Hit	Miss	Fire		Hit	Hit	Miss	Fire	
E	5	3	42	10	60	8	9	39	4	60
C	1	5	33	21	60	6	6	40	8	60

Table 13

Mean Engagement Times (Seconds)
by Scenario and Group

Group	Scenario 3	Scenario 4
E	21.65	21.73
C	22.49	21.72

Discussion

The results of the second tryout mirrored the first. Experimental subjects increased in their knowledge of stabilized gunnery, but their performance on the criterion task showed little improvement over trials. This occurred despite the changes instituted between tryouts to enhance the training effectiveness of stabilized gunnery training.

In the total set of ANOVAs performed on the FCCS scores (Trial I and Trial II), a scattering of significant F values was obtained, but, by and large, findings were not consistent. For example, in one analysis set, lasing accuracy was significant for blocks of trials; in another, engagement time for blocks was significant. On two occasions, the interaction of blocks and groups was significant. However, the interactions

were not attributable to differential gains in performance between groups. Somewhat encouraging is that in some of the non-significant comparisons the means were in the right direction.

The findings from the knowledge test analyses stand in contrast to the FCCS results. In both studies, the main effects of groups, tests, and interaction of groups and tests were all highly significant. There was ample evidence then that the experimental Ss learned about stabilized gunnery. At the same time, scores of experimental Ss on the stabilized gunnery practice tape failed to confirm any immediate effects of this acquired knowledge.

There are a number of possible reasons why the training program was ineffective in terms of FCCS performance. First, none of the training provided tracking practice, a skill required in moving platform gunnery. The Ss, OSUT trained only through conduct of fire, may not have been skilled enough in fundamentals of tracking. Secondly, verbal knowledge is not easily assimilated into the skill repertoire, even given a number of massed trials. It may be that distributed practice would have been better although probably not feasible given the demands on soldiers' time and the difficulty of guaranteeing their availability over a distributed practice schedule. A third possibility involves the criterion device, the FCCS. The device may be an inadequate simulation of stabilized gunnery, at least in one important respect--the apparent reticle motion on the device may be unlike that on M60A3 tanks. A fourth reason for the ineffectiveness of the program in terms of criterion performance could be the limited practice given on the PTD and trials on the FCCS; that is, moving platform gunnery may be such a highly skilled set of behaviors that practice beyond any time available in OSUT is required to master the skills. A corollary to this notion is that OSUT soldiers don't have the prerequisite skills (stationary gunnery) to master moving platform gunnery skills. Finally, perhaps the principles presented in the KT were incorrect and served to hinder FCCS performance rather than help.

SUMMARY AND CONCLUSIONS

A training program to provide elementary skill in M60A3 stabilized gunnery was developed. The program, centered around 14 analytically-derived principles of stabilized gunnery, is in three parts. The first, a knowledge videotape, familiarizes soldiers with "patterns" of apparent reticle movement and demonstrates the correct point in the "pattern" to lase and fire. The second product, a practice videotape, when used with a mock-up of the Gunner's periscope and control handles, provides practice in "anticipating" the reticle movement, as well as in lasing and firing. The third product, a series of tank stabilized gunnery exercises, allows soldiers to practice on M60A3 tanks some of the things presented in the knowledge videotape and practiced using the practice tape device.

The videotape training products were tried out, revised based on the tryout results, and tried out a second time. The data obtained in the two tryouts and the constraints which guided the design of training materials permit the following conclusions:

- The stabilized gunnery knowledge videotape is an effective procedure by which to present information on moving platform gunnery to soldiers. They expressed positive attitudes toward its use in a training program. The KT can be group administered using equipment available in any OSUT battalion.
- Soldiers indicated that the stabilized gunnery practice tape device enabled them to gain confidence both in their ability to anticipate the apparent reticle movement and to respond to the movement. The PTD is relatively inexpensive to produce and can be set up in a dayroom or corner of a classroom.
- The stabilized gunnery practice tape device is of little value in training soldiers to perform the tracking element of moving platform gunnery. Ss did, however, tend to decrease their lasing and firing times across sets of engagements, although with one exception these time improvements were not significant. These empirical results seem to back up Ss feeling of confidence gain.

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APPENDIXES

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APPENDIX A
ADDITIONAL BIBLIOGRAPHIC ANNOTATIONS
ON STABILIZED GUNNERY

Richard, Bellows, Henry and Co. "Studies of Naval Air Basic Training: Fixed Gunnery Phase." New York, 1967, AD660029.

This report discusses the results of studies made concerning "Naval Air Basic Training: Fixed Gunnery Phase." Section A presents the rating sheet used to determine rank or difficulty for the problems identified. In Section B the results of the Problem Rating Sheet indicate that instructors' and students' ratings differ significantly. Section C deals with the standards for grading students on Fixed Gunnery performance. The Standards are instructor ratings, percent of hits of round fired and error rates. Section D represents the example of the effect of wind on Fixed Gunnery runs.

Knauft, E.B. "Memorandum on the Use of the Correct Point-of-Aim in Gunnery Training Devices." Iowa State University, Iowa City, Iowa, October 1946, AD639278.

This memorandum provides information and suggestions for the use of the correct point-of-aim in training devices. The possible methods in which point-of-aim may be used are also discussed. Tentative conclusions and recommendations of the "Methods" discussion are as follows:

1. Gunners should be trained on a large number of different attacks in a given sector.
2. The point of aim should be continuously visible to the gunner at the first presentation.
3. One method cannot be recommended over another due to insufficient evidence and experience.
4. No evidence is available concerning the amount of learning occurring when the point-of-aim is never visible to the gunner.

Knauft, E.B. "Memorandum on Progress of Learning Study on Aerial Gunnery Training Device 3-A-2." Iowa State University, Iowa City, Iowa, October 1946, AD639277.

The memorandum briefly summarizes research conducted as of October 1946 on the nature and extent of the learning process involved in the mastery of the aerial gunnery training device 3-A-2. The results of a preliminary experiment showed progressive group improvement for the duration of the experiment and that the ceiling of performance had not been reached.

Knauft, E.B. "An Experimental Study of Learning on the Aerial Gunnery Training Device 3-A-2." Iowa State University, Iowa City, Iowa, April 1947, AD639279.

This report describes the procedure and results of an investigation of the nature and extent of the learning process involved in the mastery of aerial gunnery training device 3-A-2. Specifically, the report discusses (1) the limit of skill attainable, (2) the amount of practice required to reach this limit, and (3) the form of the learning curve.

Two experiments were conducted using graduate students from the State University of Iowa. Equipment used included projectors, films, screen and a 3-A-2.

The students fired several practice and test rounds during seventeen (17) sessions. The first experiment showed that the students did not reach a ceiling of performance.

The second experiment was conducted under similar conditions. The results were that the group reached a maximum level of performance after 25-30 practice sessions; the average maximum score ranged from 50 to 55 percent hits and the learning curve resembled the ogive curve.

Knauft, E.B. "An Experimental Study of the Effectiveness of Various Training Procedures Used With the Aerial Gunnery Training Devices 3-A-35 and 3-A-2." Iowa State University, Iowa City, Iowa, July 1946, AD639275.

This report discusses an experiment conducted to determine the effectiveness of various training methods employed with the 3-A-35 device. The experiment also addressed the mechanical defects of the experiment.

The five different experimental training and conditions were:

1. Standard 3-A-35 (Tracking targets through 100° azimuth) - four sessions.
2. a) Tracking through 100° with point-of-aim visible on screen - two sessions.
b) Tracking and leading through 100° (3-A-35) - two sessions.
3. 3-A-2 condition (small azimuth movement) - four sessions.

4. a) Combination 3-A-2 (first two sessions).
b) 3-A-35 (last two sessions).
5. 3-A-35 with "On target" lights mounted on the turret yoke. The correct point-of-arm was not visible.

The analysis of the data indicated that none of the five training methods was significantly more efficient than any of the others. The subjects preferred the 3-A-35 because it was more realistic.

Recommendations were made concerning the improvement of the equipment used.

"Gunnery Training for Tank Crews." Foreign Science and Technology Center, U.S. Army Material Command, Dept. of the Army, November 1970.

The author (unknown) proposes a gunnery training program for tank crews designed to emphasize his opinion that precision is more important than rapidity. Described are the pertinent responsibilities of each crew member, simulated gunnery target ranges and exercises. The exercises include the use of subcaliber ammunition and simulators.

The author distinguishes between tanks with or without stabilizers to the extent of the differences in vulnerability time. The author does not discuss training for stabilized tanks. The effectiveness of any training, the author contends, is dependent upon the actual and maximum use of available resources.

APPENDIX B

SCRIPT FOR MOVING PLATFORM GUNNERY KNOWLEDGE VIDEOTAPE

M60A3 STABILIZED GUNNERY

Script for Moving Platform Gunnery Knowledge Videotape

SUPERIMPOSE

Wide view of M60A3 tank.

Close-up M60A3 tank moving with gun maintaining fixed orientation in space.

1. Press head firmly against browpad.
2. Press back against seat backrest.
3. Feet flat on turret floor directly below Gunner's control handles.

Close-up view of periscope reticle superimposed on target when both the firing tank and target are stationary.

Close-up view of periscope reticle superimposed on target when firing tank is moving and target is stationary.

NARRATION

AS YOU KNOW, THE STABILIZATION SYSTEM ON THE M60A3 TANK MAKES IT POSSIBLE TO ACQUIRE TARGETS AND TO FIRE ACCURATELY ON THE MOVE. THE STABILIZATION SYSTEM IS DESIGNED TO KEEP THE GUN ORIENTED ON THE SAME POINT IN ELEVATION AND DEFLECTION REGARDLESS OF THE UP-AND-DOWN OR SIDE-TO-SIDE MOTION OF THE TANK.

THE PURPOSE OF THIS VIDEOTAPE IS TO TELL AND SHOW YOU SOME THINGS ABOUT LASING AND FIRING AN M60A3 TANK FROM THE GUNNER'S POSITION WHEN THE TANK IS MOVING. LET'S BEGIN WITH POSITIONING YOURSELF IN THE TANK. YOU ALREADY KNOW, FROM YOUR EARLIER PRACTICE FIRING WHEN THE TANK IS STATIONARY, THAT YOU MUST TAKE UP A POSITION THAT IS COMFORTABLE FOR YOU. WHEN FIRING FROM A MOVING TANK, KEEP IN MIND THREE CONTACT POINTS WHEN TAKING UP YOUR POSITION. PRESS YOUR HEAD FIRMLY AGAINST THE GUNNER'S PERISCOPE BROWPAD AND PRESS YOUR LOWER BACK AGAINST THE GUNNER'S SEAT BACKREST. PLACE YOUR FEET FLAT ON THE FLOOR AND DIRECTLY BELOW THE CONTROL HANDLES. BOTH THE DRIVER AND THE TANK COMMANDER WILL KEEP YOU CONSTANTLY INFORMED REGARDING CHANGES IN TERRAIN, OR SPEED, OR BOTH, SO YOU CAN PREPARE FOR ANY CHANGES IN TANK MOTION. REMEMBER, WHEN YOU FIND THE POSITION THAT IS MOST COMFORTABLE FOR YOU, TAKE UP THAT SAME POSITION EVERY TIME YOU ARE A GUNNER.

BY WAY OF REVIEW, HERE IS WHAT THE SIGHT PICTURE AND PERISCOPE RETICLE LOOK LIKE WHEN THE FIRING TANK IS STATIONARY AND THE TARGET IS STATIONARY. NOTICE HOW STEADY THE RETICLE IS. NOW LET'S TALK ABOUT WHAT THE SIGHT PICTURE AND PERISCOPE RETICLE LOOK LIKE WHEN THE FIRING TANK IS MOVING AND THE STABILIZATION SYSTEM IS FULLY OPERATIONAL. NOTICE THAT THE RETICLE IS MOVING AROUND THE TARGET AREA. THE MOVEMENT HAS A PATTERN OR SAMENESS TO IT THAT YOU SHOULD BE ABLE TO SEE. WATCH IT FOR A FEW MOMENTS UNTIL THE PATTERN BECOMES CLEAR TO YOU. THE MOVEMENT IS CAUSED BY

SUPERIMPOSE

NARRATION

THE STABILIZATION SYSTEM OPERATING TO KEEP THE GUN ORIENTED ON THE TARGET AS LONG AS YOU CONTINUE TO TRACK. THE SPEED OF YOUR TANK AND THE TYPE OF TERRAIN WILL INFLUENCE THE RETICLE MOVEMENT. AT CERTAIN SPEEDS THE VIBRATION IN YOUR SIGHT PICTURE WILL BEGIN TO SMOOTH OUT AND THE RETICLE WILL JUMP AROUND LESS. THESE SPEEDS ARE CALLED SWEET SPOTS. DUE TO THE DIFFERENCES BETWEEN INDIVIDUAL TANKS, YOU SHOULD EXPERIMENT OVER DIFFERENT TYPES OF ROADS AND TERRAIN AT VARIOUS SPEEDS TO DETERMINE THE SWEET SPOT FOR YOUR TANK.

Close-up view of periscope reticle superimposed on target when both firing tank and target are stationary.

WHEN OPERATING IN THE STABILIZED MODE, YOU WILL NOT HAVE A STEADY SIGHT PICTURE LIKE YOU SEE WHEN THE FIRING TANK IS STATIONARY. DURING THE NEXT PART OF THE VIDEOTAPE YOU WILL SEE WHAT THE SIGHT PICTURE AND PERISCOPE RETICLE LOOK LIKE UNDER SPECIFIC FIRING TANK AND TARGET SITUATIONS. FOLLOWING THOSE PRESENTATIONS, YOU WILL SEE WHERE, DURING THE MOVEMENT OF THE RETICLE AROUND THE TARGET AREA, YOU SHOULD LAZE AND FIRE.

SUPERIMPOSE

NARRATION

SITUATION 1

- Firing tank speed: 5mph.
- Terrain: Smooth.
- Target speed: Stationary.
- Target direction: Facing.
- Firing tank to target range: 1400 meters.

IN THE FIRST SITUATION, THE FIRING TANK IS TRAVELING 5 MILES PER HOUR ON SMOOTH TERRAIN. THE TARGET IS STATIONARY FACING THE FIRING TANK AT A RANGE OF 1400 METERS.

WHEN FIRING ON THE MOVE, YOU WILL HAVE A NATURAL TENDENCY TO USE THE GUNNER'S CONTROL HANDLES TO TRY TO MAKE THE PERISCOPE RETICLE LAY MOTIONLESS ON THE CENTER OF MASS. DO NOT TRY TO MAKE THESE FINE CORRECTIONS AROUND THE TARGET AREA. LET THE STABILIZATION SYSTEM DO THAT FOR YOU. USE YOUR CONTROL HANDLES TO TRACK THE TARGET.

SITUATION 2

- Firing tank speed: 5mph.
- Terrain: Smooth.
- Target speed: Stationary.
- Target direction: Facing.
- Firing tank to target range: 1600 meters.

THIS SECOND SITUATION IS IDENTICAL TO THE FIRST EXCEPT THAT THE FIRING TANK TO TARGET RANGE HAS BEEN INCREASED TO 1600 METERS. THE FIRING TANK IS TRAVELING 5 MILES PER HOUR ON SMOOTH TERRAIN. THE TARGET IS STATIONARY FACING THE FIRING TANK AT A RANGE OF 1600 METERS.

YOU SHOULD LAZE AND FIRE ONLY WHEN THE GUN TUBE IS OVER THE FRONT DECK. AN EXCEPTION CAN BE MADE WHEN YOU ENCOUNTER A SURPRISE TARGET ON YOUR FLANK.

SITUATION 3 (HORIZONTAL SPLIT)

- Firing tank speed: 5mph.
- Terrain: Smooth.
- Target speed: Stationary.
- Target direction: Facing.
- Firing tank to target range: 1400 meters.

-
- Firing tank speed: 5mph.
 - Terrain: Smooth.
 - Target speed: Stationary.
 - Target direction: Facing.
 - Firing tank to target range: 1600 meters.

Superimpose

- Firing tank to target range: 1400 meters.
- Firing tank to target range: 1600 meters.

NOW, LET'S LOOK AT THE FIRST TWO SITUATIONS AT THE SAME TIME. IN BOTH VIEWS, THE FIRING TANK IS TRAVELING 5 MILES PER HOUR ON SMOOTH TERRAIN. THE TARGET IS STATIONARY FACING THE FIRING TANK. THE FIRING TANK TO TARGET RANGE IS 1400 METERS FOR THE SITUATION ON THE TOP OF THE SCREEN AND 1600 METERS FOR THE SITUATION ON THE BOTTOM OF THE SCREEN.

SUPERIMPOSE

NARRATION

SITUATION 4

- Firing tank speed: 5mph.
- Terrain: Smooth.
- Target speed: 10mph.
- Target direction: Right to left.
- Firing tank to target range: 1600 meters.

DURING THIS NEXT SITUATION, THE FIRING TANK IS AGAIN TRAVELING 5 MILES PER HOUR ON SMOOTH TERRAIN. NOW, HOWEVER, THE TARGET IS ALSO TRAVELING. IN THIS CASE, FROM RIGHT TO LEFT AT 10 MILES PER HOUR AT A RANGE OF 1600 METERS.

SITUATION 5

- Firing tank speed: 5mph.
- Terrain: Rough.
- Target speed: 10mph.
- Target direction: Left to right.
- Firing tank to target range: 1000-500 meters.

THE FIRING TANK SPEED REMAINS AT 5 MILES PER HOUR. THE TERRAIN OVER WHICH THE FIRING TANK TRAVELS IS ROUGH INSTEAD OF SMOOTH. THE TARGET IS MOVING FROM LEFT TO RIGHT AT 10 MILES PER HOUR AT A RANGE WHICH BEGINS AT 1000 METERS AND DECREASES TO 500 METERS.

REMEMBER, USE YOUR GUNNER'S CONTROL HANDLES TO TRACK THE TARGET. DO NOT TRY TO MAKE FINE CORRECTIONS AROUND THE TARGET AREA. LET THE STABILIZATION SYSTEM DO THAT FOR YOU.

SITUATION 6 (HORIZONTAL SPLIT)

- Firing tank speed: 5mph.
 - Terrain: Smooth.
 - Target speed: 10mph.
 - Target direction: Right to left.
 - Firing tank to target range: 1600 meters.
-
- Firing tank speed: 5mph.
 - Terrain: Rough.
 - Target speed: 10mph.
 - Target direction: Left to right.
 - Firing tank to target range: 1000-500 meters.

Superimpose { Terrain: Smooth
Terrain: Rough

COMPARE THE SIGHT PICTURE AND PERISCOPE RETICLE MOVEMENT WHEN THE TERRAIN IS SMOOTH (TOP OF THE SCREEN) WITH THE SIGHT PICTURE AND PERISCOPE RETICLE MOVEMENT WHEN THE TERRAIN IS ROUGH (BOTTOM OF THE SCREEN). REMEMBER, THE FIRING TANK SPEED IS 5 MILES PER HOUR AND THE TARGET SPEED IS 10 MILES PER HOUR.

SUPERIMPOSE

NARRATION

SITUATION 7

- Firing tank speed: 10mph.
- Terrain: Rough.
- Target speed: 10mph.
- Target direction: Right to left.
- Firing tank to target range: 1000-500 meters.

HERE, THE FIRING TANK SPEED INCREASES TO 10 MILES PER HOUR ON ROUGH TERRAIN. THE TARGET IS MOVING FROM RIGHT TO LEFT AT 10 MILES PER HOUR AT A RANGE WHICH BEGINS AT 1000 METERS AND DECREASES TO 500 METERS.

SITUATION 8 (HORIZONTAL SPLIT)

- Firing tank speed: 5mph.
 - Terrain: Rough.
 - Target speed: 10mph.
 - Target direction: Left to right.
 - Firing tank to target range: 1000-500 meters.
-
- Firing tank speed: 10mph.
 - Terrain: Rough.
 - Target speed: 10mph.
 - Target direction: Right to left.
 - Firing tank to target range: 1000-500 meters.

Superimpose

- Firing tank speed: 5mph.
- Firing tank speed: 10mph.

IN THE NEXT SITUATION, COMPARE THE SIGHT PICTURE AND PERISCOPE RETICLE MOVEMENT WHEN THE FIRING TANK IS MOVING 5 MILES PER HOUR ON ROUGH TERRAIN (AT THE TOP OF THE SCREEN) WITH THE SIGHT PICTURE AND PERISCOPE RETICLE MOVEMENT WHEN THE TANK IS MOVING 10 MILES PER HOUR ON ROUGH TERRAIN (AT THE BOTTOM OF THE SCREEN). THE TARGET SPEED IN BOTH CASES IS 10 MILES PER HOUR AND THE RANGE DECREASES FROM 1000-500 METERS.

NOTICE THAT THE SIGHT PICTURE AND PERISCOPE RETICLE AT 10 MILES PER HOUR IS NOT SMOOTHER THAN THE PICTURE AT 5 MILES PER HOUR. THIS IS BECAUSE THE TANKS ARE ON ROUGH TERRAIN WHERE THE SWEET SPOT TENDS TO OCCUR AT SLOWER SPEEDS. THIS IS AN EXAMPLE OF THE EFFECT OF TERRAIN AND SPEED ON A TANK'S SWEET SPOT.

SITUATION 9

- Firing tank speed: 5mph.
- Terrain: Rough.
- Target speed: 10mph.
- Target direction: Right to left.
- Firing tank to target range: 1200-500 meters.

DURING THIS SITUATION, YOU WILL HEAR THE TANK COMMANDER ISSUE A FIRE COMMAND AND SEE THE GUN LAID FOR DIRECTION. YOU WILL HEAR THE GUNNER ANNOUNCE "IDENTIFIED" AS YOU SEE THE TARGET ENTER HIS FIELD OF VIEW AND YOU WILL SEE THE EFFECTS ON THE SIGHT PICTURE OF SMOKE, DUST, AND OTHER DEBRIS. THE FIRING TANK IS MOVING 5 MILES PER HOUR ON ROUGH TERRAIN. THE TARGET IS MOVING FROM RIGHT TO LEFT AT 10 MILES PER HOUR AT A RANGE WHICH BEGINS AT 1200 METERS

SUPERIMPOSE

NARRATION

AND DECREASES TO 500 METERS.

SAY: GUNNER HEAT TANK

SAY: IDENTIFIED

REMEMBER, USE YOUR GUNNER'S CONTROL HANDLES TO TRACK THE TARGET. DO NOT TRY TO MAKE FINE CORRECTIONS AROUND THE TARGET AREA. LET THE STABILIZATION SYSTEM DO THAT FOR YOU.

SITUATION 10

- Firing tank speed: 10mph.
- Terrain: Rough.
- Target speed: 10mph.
- Target direction: Advancing.
- Firing tank to target range: 1000-500 meters.

AGAIN, YOU WILL HEAR A FIRE COMMAND, SEE THE GUN LAID FOR DIRECTION AND HEAR "IDENTIFIED." THE FIRING TANK IS MOVING 10 MILES PER HOUR ON ROUGH TERRAIN. THE TARGET IS ADVANCING ON THE FIRING TANK AT 10 MILES PER HOUR AT A RANGE WHICH DECREASES FROM 1000-500 METERS.

SAY: GUNNER HEAT TANK

SAY: IDENTIFIED

SITUATION 11

- Firing tank speed: 5-7mph.
- Terrain: Rough.
- Target speed: 10mph.
- Target direction: Retreating.
- Firing tank to target range: 700-500 meters.

DURING THIS SITUATION, THE FIRING TANK SPEED WILL INCREASE FROM 5 TO 7 MILES PER HOUR AS THE TANK TRAVELS OVER ROUGH TERRAIN IN PURSUIT OF A TARGET RETREATING AT 10 MILES PER HOUR. THE RANGE TO THE TARGET WILL DECREASE FROM 700 TO 500 METERS. ALSO, YOU WILL HEAR A FIRE COMMAND, SEE THE GUN LAID FOR DIRECTION, AND HEAR "IDENTIFIED."

SAY: GUNNER HEAT TANK

SAY: IDENTIFIED

SITUATION 12

- Firing tank speed: 20mph.
- Terrain: Smooth.
- Target speed: Stationary.
- Target direction: Side.
- Firing tank to target range: 1100 meters.

REMEMBER WHAT WAS SAID EARLIER ABOUT THE SPEED OF THE TANK AND THE TYPE OF TERRAIN INFLUENCING THE RETICLE MOVEMENT? WE SAID THAT, AS A GENERAL RULE, THE FASTER THE FIRING TANK TRAVELS, THE SMOOTHER THE RETICLE MOVEMENT BECOMES. WATCH DURING THIS SITUATION AS THE FIRING TANK PROGRESSES FROM 5 MILES PER HOUR TO 20 MILES PER HOUR. YOU WILL NOTICE THE RETICLE MOVEMENT BECOME MORE UNIFORM AND SMOOTH, AND, EVEN THOUGH THE TARGET APPEARS OUT OF FOCUS, THE STABILIZATION SYSTEM AND THE GUNNER ARE ABLE TO KEEP THE GUN ORIENTED ON THE TARGET. THE FIRING TANK IS MOVING 20 MILES PER HOUR ON SMOOTH TERRAIN. THE TARGET IS STATIONARY FACING LEFT TO RIGHT AT A RANGE OF 1100 METERS.

NARRATION

NOW THAT YOU HAVE SEEN WHAT THE SIGHT PICTURE AND PERISCOPE RETICLE LOOK LIKE UNDER SPECIFIC FIRING TANK AND TARGET SITUATIONS, LET'S SEE WHERE, DURING THE MOVEMENT OF THE RETICLE AROUND THE TARGET AREA, YOU SHOULD LAZE AND FIRE. WHEN ENGAGING TARGETS FROM A MOVING TANK, YOU WILL NOT HAVE A PERFECT SIGHT PICTURE. THE RETICLE WILL BE MOVING AROUND THE TARGET AREA. YOU MUST ANTICIPATE WHEN THE RETICLE WILL MOVE TOWARD THE CENTER OF MASS AND LAZE AND FIRE IMMEDIATELY WHEN IT STARTS TO MOVE TOWARDS THE CENTER OF MASS OF THE TARGET. THE MOST IMPORTANT THING TO REMEMBER IS TO LAZE AND THEN FIRE IMMEDIATELY AS THE RETICLE MOVES TOWARD THE CENTER OF MASS OF THE TARGET. TO LAZE AND FIRE, DEPRESS AND HOLD EITHER PALM SWITCH. TRACK THE TARGET FOR AT LEAST 1-1/2 SECONDS AND DEPRESS AND RELEASE EITHER GUNNER'S THUMB SWITCH TO SET LEAD AND FIRE LASER. TO CANCEL LEAD, RELEASE PALM SWITCH. WATCH THE FOLLOWING SITUATIONS TO SEE WHERE TO LAZE AND FIRE.

SUPERIMPOSE

NARRATION

SITUATION 13

Sight picture freezes at the time
of each word.

LASE.
FIRE.

SITUATION 14

Sight picture freezes at the time
of each word.

LASE.
FIRE.

SITUATION 15

Sight picture freezes at the time
of each word.

LASE.
FIRE.

REMEMBER: ANTICIPATE WHEN THE RETICLE
WILL MOVE TOWARD THE CENTER OF MASS AND
LASE AND FIRE IMMEDIATELY WHEN IT DOES.

SITUATION 16

BECAUSE OF THE SPEED AND ACCURACY OF THE
LASER RANGEFINDER AND BALLISTIC COMPUTER,
THE BEST METHOD TO ADJUST FIRE IS TO USE
THE REENGAGE TECHNIQUE WHERE YOU TREAT
EVERY ROUND AS A SEPERATE ENGAGEMENT.
AFTER FIRING A ROUND THAT DOES NOT HIT
THE TARGET RELEASE AND THEN DEPRESS
GUNNER'S PALM SWITCH, TRACK TARGET, RELEASE
AND SET LEAD, AND FIRE A SECOND ROUND.

Sight picture freezes at sound
of each word.

LASE.
FIRE.
RELEASE.
FIRE.

SITUATION 17

Sight picture freezes at sound
of each word.

LASE.
FIRE.

OVERLAY

IF THE FIRST ROUND MISSES THE TARGET . . .
RELEASE.
FIRE.

SUPERIMPOSE

Three Contact Points

1. Press head firmly against browpad.
2. Press lower back against Gunner's seat backrest.
3. Place feet flat on turret floor.

Sweet Spot

1. The speed where vibration in sight picture smooths out and reticle jumps around less.

Tracking

1. Let stabilization system make fine corrections around the target area.
2. Use Gunner's control handles to track the target.

Front Deck

1. Lase and fire only when gun tube is over the front deck, unless
2. You encounter a surprise target on your flank.

NARRATION

LET'S REVIEW FOR A FEW MOMENTS SOME OF THE THINGS YOU LEARNED FROM THE VIDEOTAPE ABOUT LASING AND FIRING AN M60A3 TANK FROM THE GUNNER'S POSITION WHEN THE TANK IS MOVING. FIRST, KEEP IN MIND THREE CONTACT POINTS WHEN TAKING UP YOUR POSITION IN THE GUNNER'S SEAT. PRESS YOUR HEAD FIRMLY AGAINST THE GUNNER'S PERISCOPE BROWPAD AND PRESS YOUR LOWER BACK AGAINST THE GUNNER'S SEAT BACKREST. PLACE YOUR FEET FLAT ON THE FLOOR AND DIRECTLY BELOW THE CONTROL HANDLES.

SECOND, THE RETICLE MOVEMENT AROUND THE TARGET AREA IS CAUSED BY THE STABILIZATION SYSTEM OPERATING TO KEEP THE GUN ORIENTED ON THE TARGET AS LONG AS YOU CONTINUE TO TRACK. THE SPEED OF YOUR TANK AND THE TYPE OF TERRAIN WILL INFLUENCE THE RETICLE MOVEMENT. AT CERTAIN SPEEDS THE VIBRATION IN YOUR SIGHT PICTURE WILL BEGIN TO SMOOTH OUT AND THE RETICLE WILL JUMP AROUND LESS. THESE SPEEDS ARE CALLED SWEET SPOTS.

THIRD, WHEN FIRING ON THE MOVE, YOU WILL HAVE A NATURAL TENDENCY TO USE THE GUNNER'S CONTROL HANDLES TO TRY TO MAKE THE PERISCOPE RETICLE LAY MOTIONLESS ON THE CENTER OF MASS. DO NOT TRY TO MAKE THESE FINE CORRECTIONS AROUND THE TARGET AREA. LET THE STABILIZATION SYSTEM DO THAT FOR YOU. USE YOUR CONTROL HANDLES TO TRACK THE TARGET.

FOURTH, YOU SHOULD LASE AND FIRE ONLY WHEN THE GUN TUBE IS OVER THE FRONT DECK. AN EXCEPTION CAN BE MADE WHEN YOU ENCOUNTER A SURPRISE TARGET ON YOUR FLANK.

SUPERIMPOSE

NARRATION

Lase and Fire

1. Anticipate when reticle will move toward center of .
2. Lase and fire immediately when it moves toward center of mass.
3. Depress and hold either palm switch.
4. Track for at least 1-1/2 seconds.
5. Depress and release either Gunner's thumb switch.

FIFTH, YOU MUST ANTICIPATE WHEN THE RETICLE WILL MOVE TOWARD THE CENTER OF MASS AND LAZE AND FIRE IMMEDIATELY WHEN IT STARTS TO MOVE TOWARDS THE CENTER MASS OF THE TARGET. TO LAZE AND FIPE, DEPRESS AND HOLD EITHER PALM SWITCH, TRACK THE TARGET FOR AT LEAST 1-1/2 SECONDS AND DEPRESS AND RELEASE EITHER GUNNER'S THUMB SWITCH TO SET LEAD AND FIRE LASER.

Reengage

1. Reengage technique to adjust fire.
2. Release and then depress Gunner's palm switch.
3. Track target.
4. Relase.
5. Fire a second round.

SIXTH, BECAUSE OF THE SPEED AND ACCURACY OF THE LASER RANGEFINDER AND BALLISTIC COMPUTER, THE BEST TECHNIQUE TO ADJUST FIRE IS TO USE THE REENGAGE TECHNIQUE WHERE YOU TREAT EVERY ROUND AS A SEPARATE ENGAGEMENT. AFTER FIRING A ROUND THAT DOES NOT HIT THE TARGET, RELEASE AND THEN DEPRESS GUNNER'S PALM SWITCH, TRACK TARGET, RELASE AND SET LEAD, AND FIRE A SECOND ROUND.

APPENDIX C

M60A3 TANK STABILIZED GUNNERY EXERCISES

M60A3 TANK STABILIZED GUNNERY EXERCISES

The purpose of these exercises is to give the soldier an opportunity to practice some of the things he learned from the M60A3 stabilized gunnery knowledge and practice videotapes about lasing and firing the tank from the Gunner's position when the tank is moving. The exercises include:

1. Taking up the correct position in the Gunner's seat.
2. Determining the sweet spot for the tank on which he is the Gunner.
3. Tracking targets when the tank is moving.
4. Lasing and firing on targets when the tank is moving.
5. Reengaging to adjust fire.

These five exercises comprise the essential requirements for acquiring proficiency in moving platform gunnery on the M60A3 tank--they should be practiced whenever possible. The practice can be done formally, during scheduled training time; or informally, whenever the tank is moving and the soldier is in the Gunner's position. The Tank Commander is responsible for supervising the conduct of the exercises.

EXERCISE 1

Take Up Correct Position In Gunner's Seat

INTRODUCTION:

"To take up the correct position in the Gunner's seat, remember the three contact points:

1. Press your head firmly against the Gunner's periscope browpad.
2. Press your lower back against the Gunner's seat backrest.
3. Place your feet flat on the floor and directly below the control handles.

I will demonstrate the procedure to you; then you will perform the procedure."

PROCEDURE:

- a. Demonstrate the procedure by describing aloud each contact point as you "make contact". When you press your head firmly against the Gunner's periscope browpad, emphasize the importance of placing your head in the same position in the head rest each time. Point out, also, that the soldier should be aware of pressure points on the head and face which can serve as cues to correct positioning of the head.
- b. Tell soldier to get in the Gunner's seat and take up the correct position. See that his lower back is against the seat backrest and his feet are flat on the floor and directly below the control handles. Remind soldier to place his head in the same position in the head rest each time and to be aware of pressure points on the head and face which can serve as cues to correct positioning of head.
- c. Require soldier to practice taking up the correct position in the Gunner's seat until he can correctly:
 1. Place his head firmly against periscope browpad.
 2. Press his lower back against the seat backrest.
 3. Place his feet flat on the floor and directly below the control handles.

EXERCISE 2

Determine Sweet Spot

INTRODUCTION:

"The apparent reticle movement around the target area is caused by the stabilization system operating to keep the gun oriented on the target as long as you continue to track. The speed of your tank and the type of terrain will influence the reticle movement. At certain speeds the vibration in your sight picture will begin to smooth out and the reticle will appear to jump around less. These speeds are called sweet spots. During this exercise, you will learn how to determine the sweet spot for your tank. This is done by sighting through your primary sight onto a distant target over the front deck. Then, tell the Driver to move out slowly and increase his speed in 5 mile per hour increments, notifying you of each increment, until the tank speed reaches 25 miles per hour. Decide at which speed the vibration in the sight picture was least distracting and the reticle was "jumping around" least. This is the sweet spot for this tank on this type of terrain. Repeat the procedure to verify the sweet spot; then, repeat the exercise on another type of terrain. Take up the correct position in the Gunner's seat and determine the sweet spot for your tank."

PROCEDURE:

- a. Gunner takes up correct position in Gunner's seat and places the tank in the STAB mode.
- b. Gunner looks through his primary sight and selects a distant target over the front deck.
- c. Gunner tells Driver to move out slowly in the direction of the aiming point and increase his speed in 5 mile per hour increments.
- d. Gunner tells Driver to inform him of each 5 mile per hour increment until the tank speed reaches 25 miles per hour.
- e. Gunner maintains primary sight picture until tank reaches 25 miles per hour and decides at which announced speed the vibration in the sight picture was least distracting and the reticle was "jumping around" least.
- f. Gunner repeats steps b through e to verify the sweet spot.
- g. Gunner repeats the exercise on another type of terrain.
- h. Tank Commander requires Gunner to practice the exercise until the "sweet spot" verifies on each type of terrain.

EXERCISE 3

Track Targets

INTRODUCTION:

"When firing on the move, you will have a natural tendency to use the Gunner's control handles to try to make the periscope reticle lay motionless on the center of mass. Do not try to make these fine corrections around the target area. Let the stabilization system do that for you. Use your control handles to track the target. Use the same distant aiming point you used to determine the sweet spot and track that "target" as your tank moves toward it."

PROCEDURE:

- a. Gunner takes up correct position in Gunner's seat and places the tank in STAB mode.
- b. Gunner looks through his primary sight to sight on the target.
- c. Gunner tells Driver to move out slowly in the direction of the target and increase his speed until the tank's sweet spot speed is achieved.
- d. Gunner maintains primary sight picture by traversing turret left and right to track the target.
- e. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his tracking response.
- f. Tank Commander requires Gunner to practice the exercise until he can track the target in direction while letting the stabilization system make fine corrections.

EXERCISE 4

Lase and Fire on Targets

INTRODUCTION:

"When engaging targets, you must anticipate when the reticle will move toward the center of mass and lase and fire immediately when it starts to move toward the center of mass of the target. To lase and fire, depress and hold either palm switch, track the target for at least 1-1/2 seconds, and depress and release either Gunner's thumb switch to set lead and fire laser. Then press either firing trigger to fire the round. We'll use the same target we used during the tracking exercise; this time, you engage the target. Be sure to announce LASE when you set the lead and fire the laser, and ON THE WAY when you fire the round.

NOTE

Laser safety as outlined
in AR 385-22 should be
observed.

PROCEDURE:

- a. Gunner takes up correct position in Gunner's seat and places the tank in STAB mode.
- b. Gunner looks through his primary sight to sight on the target.
- c. Gunner tells Driver to move out slowly in the direction of the target and increase his speed until the tank's sweet spot speed is achieved.
- d. Gunner maintains primary sight picture by traversing turret left and right to track the target.
- e. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his tracking response.
- f. Gunner depresses and holds either palm switch and tracks target for at least 1-1/2 seconds.
- g. Gunner announces LASE and depresses and releases either thumb switch as reticle appears to move toward the center of mass of the target.
- h. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his lasing response.

- i. Gunner announces ON THE WAY and fires as the reticle appears to move again toward the center of mass of the target.
- j. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his firing response.
- k. Tank Commander requires Gunner to practice the exercise until he can lose and fire reliably.

NOTE: The Tank Commander may want to vary the exercise by including fire commands, changing targets, or changing the terrain over which the firing tank travels. Anything he chooses to do is acceptable as long as the firing tank is moving and the Gunner is required to perform the prescribed procedure.

EXERCISE 5

Reengage Targets

INTRODUCTION:

"Because of the speed and accuracy of the laser rangefinder and ballistic computer, the best technique to adjust fire is to use the reengage technique where you treat every round as a separate engagement. After firing a round that does not hit the target, release and then depress the Gunner's palm switch, track target, relase and set lead, and fire a second round. During this exercise you will engage a target and then respond to my sensings. Be sure to announce LASE whenever you set the lead and fire the laser, and ON THE WAY whenever you fire a round. Prepare to move out."

NOTE

Laser safety as outlined
in AR 385-22 should be
observed.

PROCEDURE:

- a. Gunner takes up correct position in Gunner's seat and places the tank in STAB mode.
- b. Tank Commander tells Driver to move out.
- c. Tank Commander issues fire command and lays gun for direction.
- d. Gunner looks through his unity window and announces IDENTIFIED when he sees the target.
- e. Gunner looks through his primary sight to sight on the target.
- f. Gunner tells Driver to increase his speed until the tank's sweet spot is achieved.
- g. Gunner maintains primary sight picture by traversing turret left and right to track the target.
- h. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his tracking response.
- i. Gunner depresses and holds either palm switch and tracks target for at least 1-1/2 seconds.
- j. Gunner announces LASE and depresses and releases either thumb switch as reticle appears to move toward the center of mass of the target.

- k. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his lasing response.
- l. Gunner announces ON THE WAY and fires as the reticle moves again toward the center of mass of the target.
- m. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his firing response.
- n. Tank Commander announces REENGAGE.
- o. Gunner releases palm switches momentarily, depresses and holds either palm switch, and tracks target for at least 1-1/2 seconds.
- p. Gunner announces LASE and depresses and releases either thumb switch as reticle appears to move toward the center of mass of the target.
- q. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his lasing response.
- r. Gunner announces ON THE WAY and fires as the reticle appears to move again toward the center of mass of the target.
- s. Tank Commander views sight picture through his primary sight extension and provides feedback to the Gunner regarding his firing response.
- t. Tank Commander requires Gunner to practice the exercise until he can lase and fire as the reticle appears to move toward the center of mass of the target; and, until he can adjust fire by using the reengage technique.

NOTE: The Tank Commander may want to vary the exercise by changing fire commands, changing targets, or changing the terrain over which the firing tank travels. Anything he chooses to do is acceptable as long as the firing tank is moving and the Gunner is required to perform the prescribed procedure.

APPENDIX D
KNOWLEDGE TEST

Knowledge Test, M60A3 Stabilized Gunnery

Questions 1 through 6 used in Tryout I; 1 through 8 in Tryout II

1. What 3 contact points do you keep in mind when taking your position in the Gunner's seat?

☐ Head
☐ Arms
☐ Feet
☐ Lower Back
☐ Shoulders

2. When firing while your tank is moving, what technique should you use to adjust fire?

☐ Subsequent Engagement Technique
☐ Reengage Technique
☐ Burst-On-Target Technique

3. When firing on the move, the reticle will move around the target area. You should use the Gunner's control handles:

☐ To make the reticle lay motionless on the target
☐ To track the target

4. When firing on the move, you should lase and fire as the reticle:

☐ Moves toward the center of mass of target
☐ Is at the center of mass of target
☐ Is approaching any part of target

5. When firing on the move, the vibration in your sight picture will begin to smooth out at certain speeds. These speeds are called:

6. As a general rule, you should fire on the move only when the gun tube is:

☐ Over the rear deck
☐ Over the flank
☐ Over the front deck

7. When your tank is moving, the amount of movement your reticle makes depends upon:

☐ Your tank speed and the terrain you are on
☐ The target speed and the terrain it is on
☐ The target size and its range

8. Before you press the lase-lead thumb switch, you should:

☐ Announce ON THE WAY
☐ Track the target for 1-1/2 seconds
☐ Release the palm switches

APPENDIX E
ANOVA FOR TRYOUT I

Table E-1

Analysis of Variance
Experimental Group 1
Stabilized Gunnery Practice

Lasing Time

Source of Variation	SS	df	MS	F	Sig
Between people	26.77	9			
Within people		10			
Practice sets	.72	1	.72	.77	NS
Residual	8.34	9	.93		
Total	35.84	19			

$$F_{.95}(1,9)=5.12$$

Lasing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between people	2	9			
Within people	13	10			
Practice sets	0.8	1	0.8	.59	NS
Residual	12.2	9	1.35		
Total	15	19			

$$F_{.95}(1,9)=5.12$$

Table E-2

Analysis of Variance
Experimental Group 1
Stabilized Gunnery Practice

Firing Time

Source of Variation	SS	df	MS	F	Sig
Between people	32.04	9			
Within People	2.63	10			
Practice sets	0.00	1	0.00	0.00	NS
Residual	2.63	9	.29		
Total	34.76	19			

$$F_{.95}(1,9)=5.12$$

Firing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between people	15.05	9			
Within people	13.50	10			
Practice sets	.45	1	.45	.31	NS
Residual	13.05	9	1.45		
Total	28.55	19			

$$F_{.95}(1,9)=5.12$$

Table E-3

Analysis of Variance
Experimental Group 2
Stabilized Gunnery Practice

Lasing Time

Source of Variation	SS	df	MS	F	Sig
Between people	33.13	9			
Within people	6.11	30			
Practice sets	.84	3	.28	1.4	NS
Residual	5.27	27	.20		
Total	39.24	39			

$$F_{.95}(3,27)=2.96$$

Lasing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between people	5.6	9			
Within people	20.0	30			
Practice sets	3.8	3	1.27	2.11	NS
Residual	16.2	27	.6		
Total	25.6	39			

$$F_{.95}(3,27)=2.96$$

Table E-4
Analysis of Variance
Experimental Group 2
Stabilized Gunnery Practice

Firing Time

Source of Variation	SS	df	MS	F	Sig
Between people	33.53	9			
Within people	16.33	30			
Practice sets	.45	3	.15	.25	NS
Residual	15.88	27	.59		
Total	49.86	39			

$$F_{.95}(3,27)=2.96$$

Firing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between people	10.77	9			
Within people	25.20	30			
Practice sets	.87	3	.29	.32	NS
Residual	24.33	27	.90		
Total	35.77	39			

$$F_{.95}(3,27)=2.96$$

Table E-5

Analysis of Variance
FCCS Lasing Accuracy

Source of Variation	SS	df	MS	F	Significance
Between Groups	10.42	2	5.21	.40	NS
Error _B (Ss within groups)	350.07	27	12.96		
Within Tests	13.09	2	6.54	2.22	NS
Groups X Tests	9.71	4	2.43	.83	NS
Error _W Ss within groups X tests)	158.53	54	2.94		
Total	541.82	89			

$$F_{.95}(2,27) = 3.35$$

$$F_{.95}(2,54) = 3.17$$

Table E-6
Analysis of Variance
FCCS Firing Accuracy

Source of Variation	SS	df	MS	F	Significance
Between					
Groups	15.0	2	7.5	1.1	NS
Error _B (Ss within Groups)	186.8	27	6.9		
Within					
Tests	4.3	2	2.1	.8	NS
Groups X Trials	13.6	4	3.4	1.3	NS
Error _W (Ss within Groups X tests)	138.8	54	2.6		
Total	358.5	89			

$$F_{.95}(2,27) = 3.35$$

$$F_{.95}(2,54) = 3.17$$

Table E-7

Analysis of Variance
FCCS Engagement Time

Source of Variation	SS	df	MS	F	Significance
Between Groups	95.83	2	47.91	1.07	NS
Error _B (Ss within groups)	1201.52	27	44.50		
Within Tests	16.99	2	8.49	2.86	NS
Groups X Tests	15.37	4	3.84	1.29	NS
Error _W (Ss within groups X tests)	160.45	54	2.97		
Total	1490.16	89			

 $F_{.95}(2,27)=3.35$
 $F_{.95}(2,54)=3.17$

APPENDIX F
ANOVA FOR TRYOUT II

Table F-1
Analysis of Variance
Experimental Group
Stabilized Gunnery Practice

Lasing Time

Source of Variation	SS	df	MS	F	Sig
Between people	3834.6	11			
Within people	1896.6	36			
Block	357.1	3	119.03	2.55	NS
Residual	1539.5	33	46.65		
Total	5731.2	47			

$$F_{.95}(3,33) = 2.89$$

Lasing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between people	10.67	11			
Within people	38.00	36			
Blocks	6.17	3	2.06	2.14	NS
Residual	38.83	33	.96		
Total	48.67	47			

$$F_{.95}(3,33) = 2.89$$

Table F-2
Analysis of Variance
Experimental Group
Stabilized Gunnery Practice

Firing Time

Source of Variation	SS	df	MS	F	Sig
Between people	7655.94	11			
Within people	790.44	36			
Blocks	278.29	3	92.76	5.98	< .01
Residual	512.15	33	15.52		
Total	8446.38	47			

$$F_{.99}(3,33) = 4.46$$

Firing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between people	13.73	11			
Within people	15.25	36			
Blocks	1.56	3	.52	1.27	NS
Residual	13.69	33	.41		
Total	28.98	47			

$$F_{.95}(3,33) = 2.89$$

Table F-3
Analysis of Variance
FCCS Lasing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between					
Groups	108.30	1	108.30	3.73	NS
Error _b (Ss within groups)	639.17	22	29.05		
Within					
Blocks	23.92	4	5.98	2.01	NS
Groups X Blocks	23.78	4	5.94	2.00	NS
Error _w (Ss within groups X blocks)	261.50	88	2.97		
Total	1056.67	119			

$$F_{.95}(1,22) = 4.30$$

$$F_{.95}(4,88) = 2.48$$

Table F-4
Analysis of Variance
FCCS Firing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between Groups	6.54	1	6.54	.47	NS
Error _b (Ss within groups)	305.53	22	13.89		
Within Blocks	12.80	4	3.20	2.19	NS
Groups X Blocks	7.46	4	1.86	1.27	NS
Error _w (Ss within groups x blocks)	128.14	88	1.46		
Total	460.47	119			

$$F_{.95}(1,22) = 4.30$$

$$F_{.95}(4,88) = 2.48$$

Table F-5
Analysis of Variance
FCCS Lasing Accuracy Plus Firing Accuracy

Source of Variation	SS	df	MS	F	Sig
Between					
Groups	21.68	1	21.68	1.95	NS
Error _b (Ss within groups)	244.25	22	11.10		NS
Within					
Blocks	6.30	4	1.57	.39	NS
Groups X Blocks	9.53	4	2.38	.59	NS
Error _w (Ss within groups X blocks)	355.17	88	4.04		
Total	636.93	119			

$$F_{.95}(1,22) = 4.30$$

$$F_{.95}(4,88) = 2.48$$

Table F-6
Analysis of Variance
Engagement Time

Source of Variation	SS	df	MS	F	Sig
Between					
Groups	3.19	1	3.19	.05	NS
Error _b (Ss within groups)	1394.14	22	63.37		
Within					
Blocks	101.67	4	25.82	2.88	< .05
Groups X Blocks	6.11	4	1.53	.17	NS
Error _w (Ss within groups x blocks)	776.49	88	8.82		
Total	2281.60	119			

$F_{.95}(1,22) = 4.30$

$F_{.95}(4,88) = 2.48$

Table F-7
Analysis of Variance
FCCS Lasing Accuracy (Posttest, Part I Only)

Source of Variation	SS	df	MS	F	Sig
Between Groups	92.04	1	92.04	3.51	NS
Error _b (Ss within groups)	576.67	22	26.21		
Within Blocks	22.08	3	7.36	3.32	.05
Groups X Blocks	23.33	3	7.78	3.50	.05
Error _w (Ss within Groups X blocks)	146.83	66	2.22		
Total	860.95	95			

$$F_{.95}(1,22) = 4.30$$

$$F_{.95}(3,66) = 2.75$$

Table F-8
Analysis of Variance
FCCS Lasing Accuracy
(Easy Scenario)

Source of Variation	SS	df	MS	F	Sig
Between Groups	21.60	1	21.60	3.60	NS
Error _b (Ss within groups)	128.92	22	5.86		
Within Blocks	14.28	4	3.57	17.17	< .001
Groups X Blocks	4.78	4	1.20	5.75	< .001
Error _w (Ss Within groups X blocks)	18.33	88	.21		
Total	187.91	119			

$$F_{.95}(1,22) = 4.30$$

$$F_{.999}(4,88) = 5.12$$

Table F-9
Analysis of Variance
Engagement Time
(Easy Scenario)

Source of Variation	SS	df	MS	F	Sig
Between Groups	464.92	1	464.92	.23	NS
Error _b (Ss within groups)	45,027.89	22	2046.72		
Within Blocks	8,614.86	4	2153.72	13.44	< .001
Groups X Blocks	49.39	4	12.35	.08	NS
Error _w (Ss within groups x blocks)	14,103.11	88	160.26		
Total	68,260.17	119			

$$F_{.999} (4,88) = 5.12$$